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Title: METHOD AND DEVICE FOR TIGHTENING THREADED JOINTS. ;

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ABSTRACT:

The invention concerns a method and a device for tightening threaded joints in two subsequent steps, namely a first step during which a joint is tightened to a predetermined torque snug level and a second step during which the joint is further tightened up to a final predetermined pretension level. During the second tightening step the torque delivered by the power tool (10) comprised in the device is gradually increased at a rate exceeding the highest torque rate expected from the joint to be tightened. The power tool (10) comprises an electric brushless AC-motor which is supplied with power from a variable frequency output inverter (11), and the gradual increase in output torque from the power tool (10) is accomplished by the phase lag in the AC-motor as a result of a gradually increased output frequency from the power supply means (11).

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(54) Method and device for tightening threaded joints.

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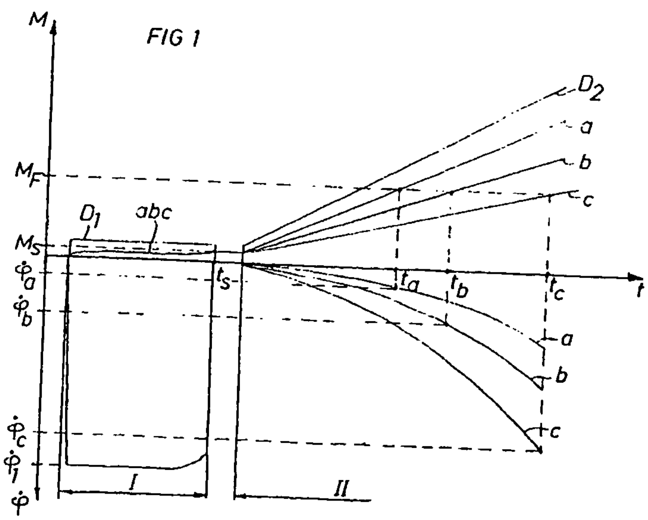
FIG 1



EP 0 419 435 A2

METHOD AND DEVICE FOR TIGHTENING THREADED JOINTS

This invention relates to a method and device for tightening threaded joints in two subsequent steps, namely a first step during which a joint is tightened to a predetermined torque snug level and a second step during which the joint is further tightened up to a final predetermined pretension level.

The main purpose of the invention is to accomplish a method and a device by which a threaded joint is tightened up to a predetermined pretension level during the second tightening step and by which the stiffness that varies from joint to joint is prevented from causing an undesirable scattering of the obtained pretension level as well as a tiresome jerky reaction torque characteristic to be handled by the operator.

By governing the increase rate of the torque application it is possible to obtain a tightening process which is advantageous both from the ergonomic and the pretension accuracy point of view. The method and the device according to the invention are particularly intended for manually supported tightening tools by which the tiring and uncomfortable jerks normally occurring at the end of the tightening process are elimnated.

The torque growth characteristic depends on a number of factors such as the power of the tool, the rotation speed of the tool, the characteristic of the threaded joint etc. For a certain tool, however, the torque growth is always a function of the threaded joint characteristic, such as if the threaded joint has a weak characteristic with a slow torque growth in relation to the angle of rotation or a stiff characteristic with a steep torque growth in relation to angle of rotation, the torque growth of the tool will vary correspondingly.

The optimum torque growth speed from the ergonomic point of view depends on several parametres such as

1. The strength of the operator.
2. The operator's ability to react fast.
3. The torque level.
4. The torque snug level, if used.
5. The operator's work position.
6. The shut-off speed.

Since there are several parametres involved, it is realized that from the ergonomic point of view it is important to be able to adjust the torque growth speed for obtaining a good reaction torque characteristic.

By the invention, the above problems are solved in that the torque growth speed in the second step is controlled to correspond to man's ability to respond to the developed reaction torque.

In the torque range of 15-150 Nm, suitable torque growth values should be 25-150 Nm/s, whereas in the torque range above 150 Nm 250 Nm/s in combination with short tightening times 0,1 - 0,2 s are suitable. In the latter case, the process time is too short for the operator to react at all.

The method and device according to the invention will be described in further detail below with reference to the drawings.

On the drawings:

Fig 1 shows a diagram illustrating the torque growth when using a method and a device according to the invention.

Fig 2 shows schematically a device according to one embodiment of the invention.

Fig 3 shows a device according to another embodiment of the invention.

In Fig 1 there is shown a three-axes diagram illustrating the relationship between torque designated M, the angle speed designated $\dot{\phi}$ and time t. Following the horizontal time axis, the first tightening step I is illustrated at the left and the second subsequent tightening step II is illustrated at the right. The first tightening step I is commenced in that a constant torque D1 is applied on the threaded joint. D1 represents the torque developed by the power tool, whereas the reaction torque from the threaded joint is illustrated by a curve abc. As the installed torque in the threaded joint, curve abc, has reached a snug level M_s, the torque application from the power tool is ceased. The first tightening step is completed.

Looking at the angle speed illustrated below the horizontal time axis, there is shown a very steep acceleration of the joint up to an angle rotation level $\dot{\phi}$ which remains substantially constant up to the point t_s in which the torque snug level M_s is reached.

When starting the second step, a torque D2 developed by the power tool is successively increased from a level corresponding to the torque level D1 of the first tightening step. According to the illustration of Fig 1, the applied torque D2 is gradually increased along a straight line. To illustrate the reaction torque from the threaded joint, there are illustrated three different joint characteristics a, b, and c which represent joints of different stiffness. Curve $\underline{a}$ represent the stiffest joint and c the weakest joint. The increase rate of the applied torque D2 is chosen to be well above even the stiffest joint characteristic $\underline{a}$. This means that in every point on the time axis that part of the applied torque which exceeds the torque reaction from the threaded joint will cause an acceleration of the system, and the weaker the threaded joint characteristic i, the higher the acceleration. This is

illustrated by the curves below the horizontal axis where the angular rotation curves a,b, and c correspond to the torque characteristic curves illustrated above the horizontal axis. Accordingly, the weakest joint c is exposed to the highest acceleration which is illustrated by the steepest curve c in the $\dot{\phi}$ diagram and the stiffest joint characteristic a corresponds to the slowest acceleration curve a in the $\dot{\phi}$ diagram.

The threaded joints are intended to be pretensioned up to a final predetermined level corresponding to a torque M_F, and dependent on how stiff the torque/time characteristic of the actual joint the second tightening step will last for different time intervals. This means that the weakest joint c will take the longest time to finish, while joint a with the steepest torque/angle characteristic will be finished in the shortest time t_a.

Looking now at the most significant features of the present invention, it is to be noted that due to the acceleration of the tightening speed and due to the fact that the acceleration rate is different between stiff and weak joints, the angle speed will be significantly different at the end of the second tightening step for the different joints. The final pretension level is reached very quickly by joint a which has a steep torque/angle characteristic. However, the surplus torque from the power tool which causes the acceleration of the joint is rather small at joint a which means that the acceleration is low. This means in turn that the time consumed is short and the final angle speed $\dot{\phi}$ a is low. On the other hand, joint c is exposed to a higher acceleration due to a greater torque overshoot from the power tool. Since joint c also takes a longer time to reach the pretension level M_F, the final angle speed $\dot{\phi}$ c is much higher than the final speed for joint a .

The resultant advantage of the new method and device according to the invention is that for a stiff joint, which reaches its final pretension level very quickly, the angle speed at the end of the tightening process is brought down and the torque overshoot is substantially reduced, whereas the end speed at a weak joint c, which reaches its final pretension level less abruptly, is higher. Because of the weak characteristic of the latter, the kinetic energy of the rotating parts will not cause any significant torque overshoot despite a relatively high final angle speed.

The device illustrated in Fig 2 comprises an electrically powered tightening tool 10 comprising a brushless AC-motor, a power supply means 11 and a control unit 12. The power supply means 11 comprises an inverter which is fed with DC power from a DC power source 14 and which delivers AC power of variable frequency and voltage amplitude to the tool 10.

A power detecting means 15 is provided between the DC power source 14 and the power supply means 11 and is connected to the control unit 12. To the latter there is also connected a torque rate adjusting means 16 by which a desirable value of the torque changing speed may be set.

The control unit 12 comprises a programmable processor in which all necessary data for a two-step tightening process are installed.

The device illustrated in Fig 3 differs from the device in Fig 2 in that the power tool carries a sensing means 25 for detecting the actual torque values during operation of the tool. This sensing means 25 is connected to a comparating unit 26 in which the actual sensed torque values are compared to a desired set value. As the actual sensed value reaches the preset value a signal is delivered to the control unit 12.

A preferable way to accomplish the above described control of the applied torque when using an inverter drive for an AC-powered tool is to perform the acitve control on the AC frequency supplied to the tool. The drive frequency which in fact is determining for the angle speed of the tool is increased in a certain way to generate a phase lag in relation to the joint. This phase lag is in turn generative of an increasing drive torque in the motor of the tool.

Claims

1. Method for tightening a threaded joint in two subsequent steps, comprising a first step during which the joint is tightened to a predetermined pretension snug level, and a second step during which the joint is further tightened to a final predetermined pretension level,
characterized in that said second step comprises a time related gradual increase of the torque applied on the joint from said snug level to said predetermined pretension level in the joint or to a point where the angle speed has reached a predetermined maximum level.

2. Method according to claim 1 or 2, wherein the tightening torque is applied by an electric brushless AC-motor tool powered by a variable frequency output power supply means, said gradually increasing torque applied-on the joint being generated by an advanced and continuously increasing output frequency from said power supply means.

3. Device for tightening a threaded joint in two subsequent steps, comprising a power tool (10), a power supply means (11) connected to said power tool (10), and a control means (12), **characterized in** that said control means (12) comprises a programable unit for changing during tightening and in relation to time a torque related parameter of the power supplied to said power tool (10).

4. Device according to claim 3, wherein said control unit (12) comprises an adjusting means by which the time related changing rate of said torque related parameter is set.

5. Device according to claim 3 or 4, wherein said power tool comprises an electric brushless AC-motor, and said power supply means (11) comprises a variable frequency output inverter, said torque related parameter is the output frequency of said inverter, and said adusting means being arranged to enable setting of the frequency changing rate of AC-power output from said inverter.

6. Device according to claim 5, wherein said control means comprises a microprocessor in which a circuit is arranged to provide a ramp for gradually increasing the output frequency of said inverter during tightening.

FIG 1

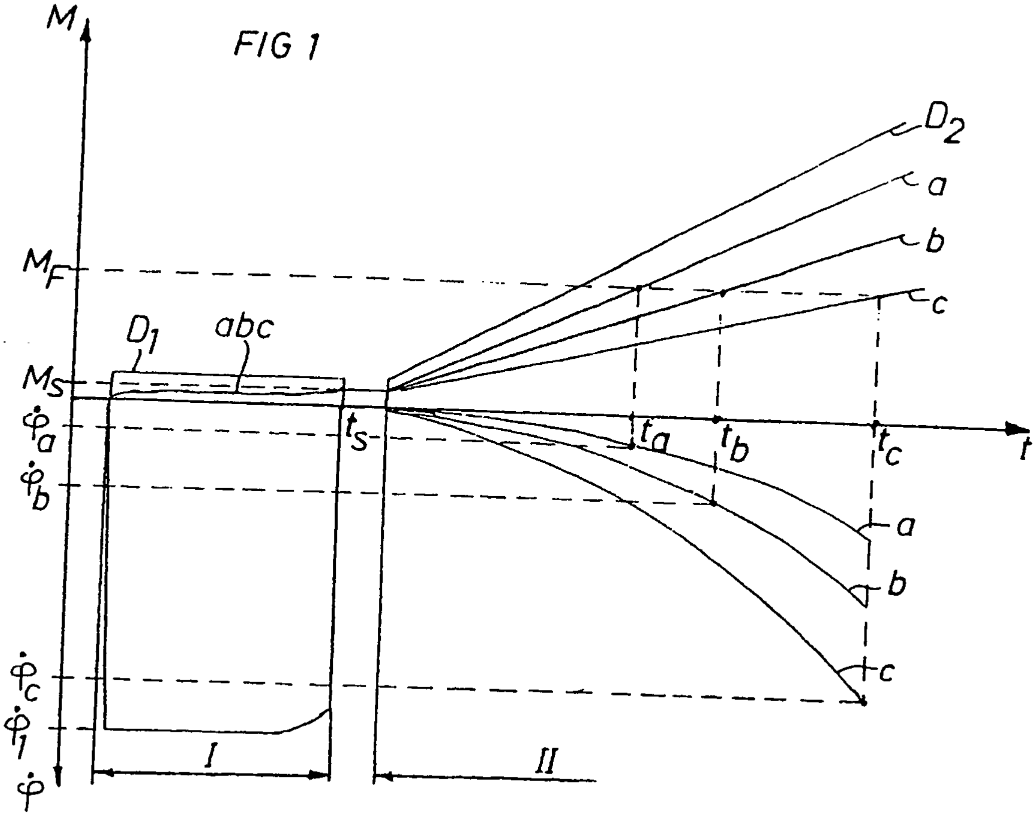


FIG 2

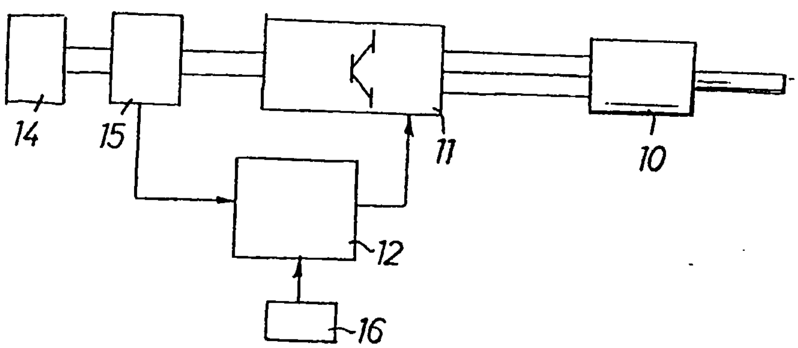
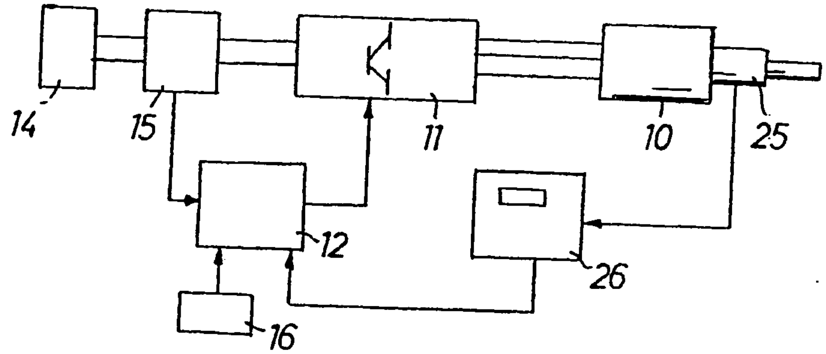


FIG 3



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Inventor(s): BEHRENS AXEL; FETZER GERHARD; MAIER PETER ;

Applicant(s): FESTO KG (DE) ;

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Equivalents:

ABSTRACT:

A current supply unit having a socket (16) for at least one electrical tool (12), which can be connected thereto by means of a connecting cable (15), with brushless motor, in particular asynchronised motor, is proposed, the current supply unit (13) having a device for adjustably presetting the supply frequency. This current supply unit (13) is designed as a plug-in device for an appliance (10) which can be used in conjunction with the electrical tool (12) and having at least one corresponding plug-in channel, a front housing wall (14) of the current supply unit (13), provided with the socket (16) and control and monitoring elements (17, 18), in the plugged-in state essentially shutting off the plug-in opening of the plug-in channel. As a result, this current supply unit (13) can be used in combination with the appliance (10), for example designed as a vacuum cleaner, but also independently from the latter. The current supply unit can be replaced quickly and simply.